Plumbbob
ITR 1402

(No WT issued)

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ITR-1402

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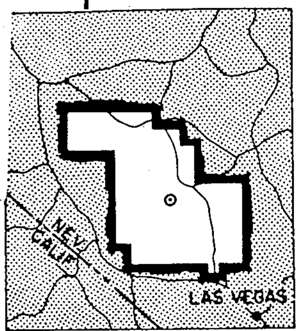
PRELIMINARY REPORT

OPERATION
PLUMBBOB



NEVADA TEST SITE
MAY-SEPTEMBER 1957

Project 1.2

FIELD TEST OF A SYSTEM FOR MEASURING BLAST PHENOMENA BY AIRBORNE GAGES

HEADQUARTERS FIELD COMMAND,
ARMED FORCES SPECIAL WEAPONS PROJECT
SANDIA BASE, ALBUQUERQUE, NEW MEXICO

[redacted]

This is a preliminary report based on all data available at the close of this project's participation in Operation PLUMBBOB. The contents of this report are subject to change upon completion of evaluation for the final report. This preliminary report will be superseded by the publication of the final (WT) report. Conclusions are recommendations drawn herein, if any, are therefore tentative. The work is reported at this early time to provide early test results to those concerned with the effects of nuclear weapons and to provide for an interchange of information between projects for the preparation of final reports.

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5 July 1995

MEMORANDUM FOR DEFENSE TECHNICAL INFORMATION SYSTEM
ATTENTION: OCD/Mr. Bill Bush

SUBJECT: Withdrawal of AD-B951745 from DTIC System

The Defense Nuclear Agency Security Office requests the withdrawal of the subject report from the DTIC system.

Since the original version of the report (ITR-1402) is declassified and approved for public release, the extracted version (B951745) is obsolete.

A copy of the original report is enclosed for inclusion into the DTIC system, since this office has no record of DTIC being on the distibution list.

Notification of the DTIC accession number would be appreciated.

FOR THE DIRECTOR:

JOSEPHINE B. WOOD
Chief, Technical Support

Enclosure:
As Stated

[redacted]

ITR–1402

OPERATION PLUMBBOB—PROJECT 1.2

FIELD TEST OF A SYSTEM FOR MEASURING BLAST PHENOMENA BY AIRBORNE GAGES

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Issuance Date: October 11, 1957

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[redacted]

ABSTRACT

Project 1.2 participated in Operation Plumbbob in order to proof test prototype air-blast instrumentation for Operation Hardtack and to train personnel in handling this experiment under field conditions. The air-blast systems consisted of (1) parachute-supported canisters containing self-recording mechanical pressure gages that were deployed by means of rockets and (2) balloon-supported pressure instrumentation.

Four fully instrumented rockets were fired successfully. With the exception of one, the rockets performed satisfactorily. The fourth rocket functioned normally through parachute deployment, at which time the after body over-rode the parachute and became entangled, causing an abnormally fast rate of descent. In spite of the malfunction, a pressure record was obtained. This type of malfunction can be corrected.

The test of the balloon system was limited as a result of the pretest loss of three of the four balloons. The limited experiment (one balloon was flown at a height of 200 feet above the surface supporting one gage at an altitude of 25 feet) was successful. However, in light of the experience gained, it is apparent this system must be modified. The load supported by the balloons must be reduced.

The pressure and recording equipment were used with both the balloon and rocket systems. Pressure-time records were obtained in all cases except one. In one of the rockets a pressure record was not obtained, due to a failure in the electrical system. There were several defects noted in the system, none of which are considered serious. The general performance of the system was satisfactory. It was concluded that the basic design was sound.

[redacted]

FOREWORD

This report presents the preliminary results of one of the 43 projects comprising the Military Effects Program of Operation Plumbbob, which included 28 test detonations at the Nevada Test Site in 1957.

For overall Plumbbob military-effects information, the reader is referred to the "Summary Report of the Director, DOD Test Group (Programs 1–9)," ITR–1445, which includes: (1) a description of each detonation, including yield, zero-point location and environment, type of device, ambient atmospheric conditions, etc.; (2) a discussion of project results; (3) a summary of the objectives and results of each project; and (4) a listing of project reports for the Military Effects Program.

PREFACE

The participation of the U. S. Naval Ordnance Laboratory in Operation Plumbbob was limited in the sense that the mission of Project 1.2 was not to gather weapon-effect data. Project 1.2 was limited to the test and training of personnel in the use of prototype instrumentation currently under development for ultimate use on Operation Hardtack.

This test was carried out by personnel of the Naval Ordnance Laboratory and the American Machine and Foundry Company. The American Machine and Foundry Company has been the contractor (NORD 17476).

Preliminary testing of the Hardtack instrumentation was carried out at the National Advisory Committee for Aeronautics Facility at Wallops Island, Virginia, and at the U. S. Naval Proving Ground, Dahlgren, Virginia. These tests were limited in their scope. For example, it was not possible to check the time and pressure recording system, the firing programming system, and the parachutes and balloons under shock conditions. Participation during Shot Owens made it possible to check with few exceptions the prototype system.

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Chapter 1
INTRODUCTION

1.1 OBJECTIVES

Project 1.2 was formed by the U. S. Naval Ordnance Laboratory to participate on Shot Owens of Operation Plumbbob. The primary objective was to field test air-blast instrumentation under development for use on the two underwater shots of Operation Hardtack, and the secondary objective was to train personnel in handling the equipment under operational conditions in the field.

1.2 BACKGROUND AND THEORY

The Naval Ordnance Laboratory plans to make air-blast measurements on the two underwater shots of Operation Hardtack: Shot Umbrella, a low-yield (8 kt) device fired on the bottom in approximately 150 feet of water and Shot Wahoo, a low-yield (8 kt) device in free water a depth of approximately 500 feet.

For Shot Umbrella, it is proposed to obtain measurements of the blast wave in air as a function of time and distance. From these data it is intended to derive the peak shock overpressure as a function of distance from surface zero, the arrival times of the initial and subsequent pulses, the relative magnitudes of the shock transmitted at the water surface and that produced by the venting of the bubble, the positive duration of the blast wave, and the positive impulse.

These measurements would be made to include the 0.5 psi peak shock overpressure region, which is of particular interest in terms of aircraft delivery. Preliminary estimates indicate that the 0.5-psi region should be less than 15,000 feet above surface zero and no farther out than 7,500 feet along the surface.

The objectives for Shot Wahoo are essentially the same as those of Shot Umbrella. However, measurements will not be as extensive.

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Chapter 2

INSTRUMENTATION

Project 1.2 tested the prototype Hardtack instrumentation on Shots Owens and Kepler. Owens was a daylight shot, suspended from a balloon 500 feet above the ground. Kepler was a predawn shot fired on a 500-foot tower.

2.1 THE AIR-BLAST INSTRUMENTATION SYSTEM

Four parachute-supported canisters, containing the pressure recording system, the internal timing system, and components of the recovery system, were deployed by rockets fired by means of a firing programmer from Station 9-1.2-90011 (N857,044.2 E672,693.54 Z4201' MSL). The positions of the parachute-supported canisters were determined photographically.

One instrument canister containing the pressure-recording system (identical to the type used in the rockets) was suspended from a balloon tethered at Station 9-1.2-9002 (N861,000 E675,500 Z4230' MSL).

Figure 2.1 shows the rocket and the balloon stations with respect to the Owens ground zero and the EG&G photographic stations.

2.1.1 Rocket Instrumentation. The instrumentation rocket is made up of two basic sections connected by means of a Marmon clamp retrained by explosive bolts. The forward body contains the self-recording mechanical scratch gage, the timing equipment, the recovery equipment (not used on this shot), and the parachute shroud ring to which the shroud lines of the parachute are attached. The after body contains the parachute and the rocket engine. The general layout is shown in Figure 2.2. The rocket and the rocket launcher are shown in Figure 2.3.

Relatively little can be said with certainty as to what the pressure field in air above an underwater nuclear burst will be. The transmitted shock, coupled with the venting of the bubble, will result in complex blast phenomena that would not be resolvable by the photographic arrival-time methods used in the past. A serious examination (Reference 1) of this problem led to the conclusion that the pressure field of interest can be best instrumented if tethered balloons are used to support pressure gages for low-altitude measurements and if parachute-supported canisters containing self-recording gages are deployed by means of rockets in order to obtain the required measurements at the higher altitudes. It was concluded that the low-altitude instrumentation should extend to approximately 1,000 feet above the surface and the high-altitude instrumentation should be used to obtain all measurements above 1,000 feet.

In general, the rocket operates as follows: A few seconds prior to firing, the electric timers, which are used to actuate the explosive bolts, are charged; the recording system is started; and the pyratimers (back up) are ignited. Upon firing, the electric and mechanical timers are actuated; and at a predetermined time, a firing pulse is delivered to the explosive bolts, causing the Marmon clamp to be blown free. Upon release of the Marmon clamp, dive brakes on the after body are released, and the rocket separates. The parachute deploys and supports the forward body, which contains the in-

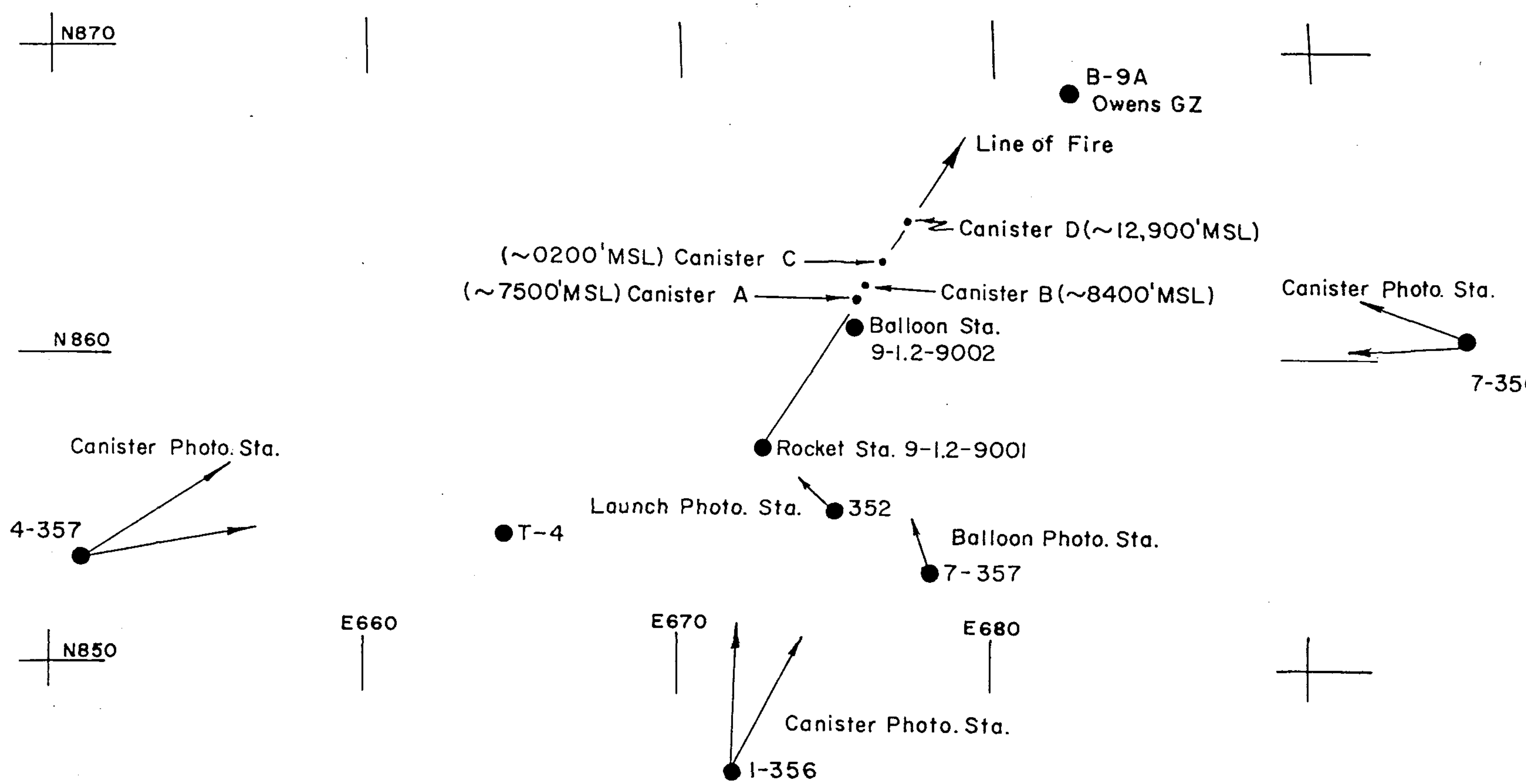

Figure 2.1 Project plot plan.

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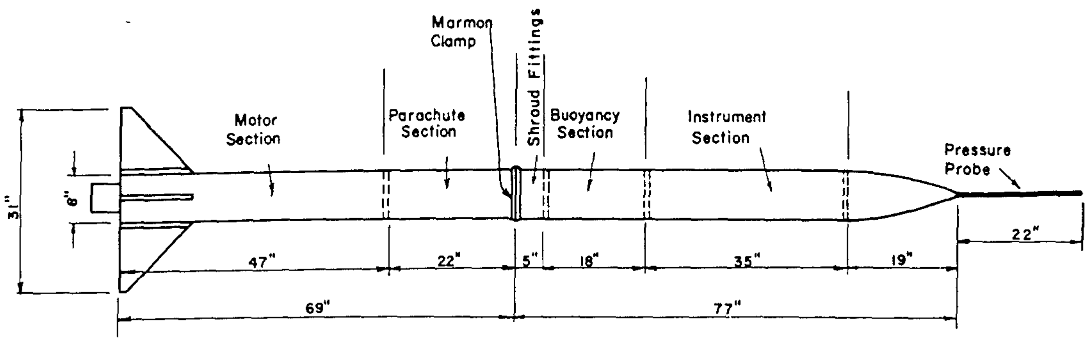

Figure 2.2 General layout of rocket.

strument section. Prior to shock arrival, the explosive valve is actuated, and the reference pressure chamber is sealed. Pressure measurements are made by the recorder during its descent. (The rate of descent is approximately 40 ft/sec.) A block diagram of the sequence of events is given in Figure 2.4.

Rocket Engine. For Plumbbob two types of engines, the M58 and the 5."0 HVAR, were used. The M58 produced a 6,670 lb-sec impulse and 5."0 HVAR produced an impulse of 5,000 lb-sec. The impulse of the 5."0 HVAR is approximately 5,200 lb-sec. The 5,000 lb-sec impulse was obtained by the grain length being shortened and the resulting space being filled with an inert material. Prior to Plumbbob, during preliminary testing, modified 5."0 HVAR engines with a thrust of 3,000 lb-sec were successfully fired.

One of the major sources of error in accurate canister placement is the uncertainty of the lapse of time between rocket separation (parachute ejection) and parachute deployment. This error may be kept at a minimum, if the speed of the rocket at separation is low (500 ft/sec or less). In order to keep the rocket speed at separation low and to obtain sufficient flexibility in range and altitude capability, rocket engines of different impulse are required.

Timing and Firing System. A program timer was used to accept the timing signals from Edgerton, Germeshausen & Grier (EG&G) to produce the required time sig-

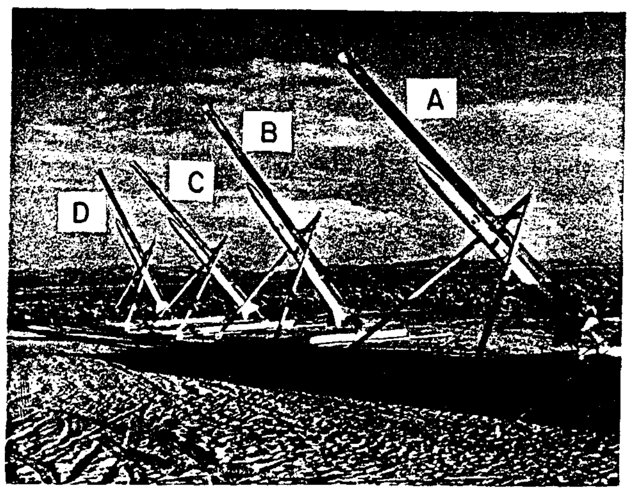

Figure 2.3 Rockets in firing position.

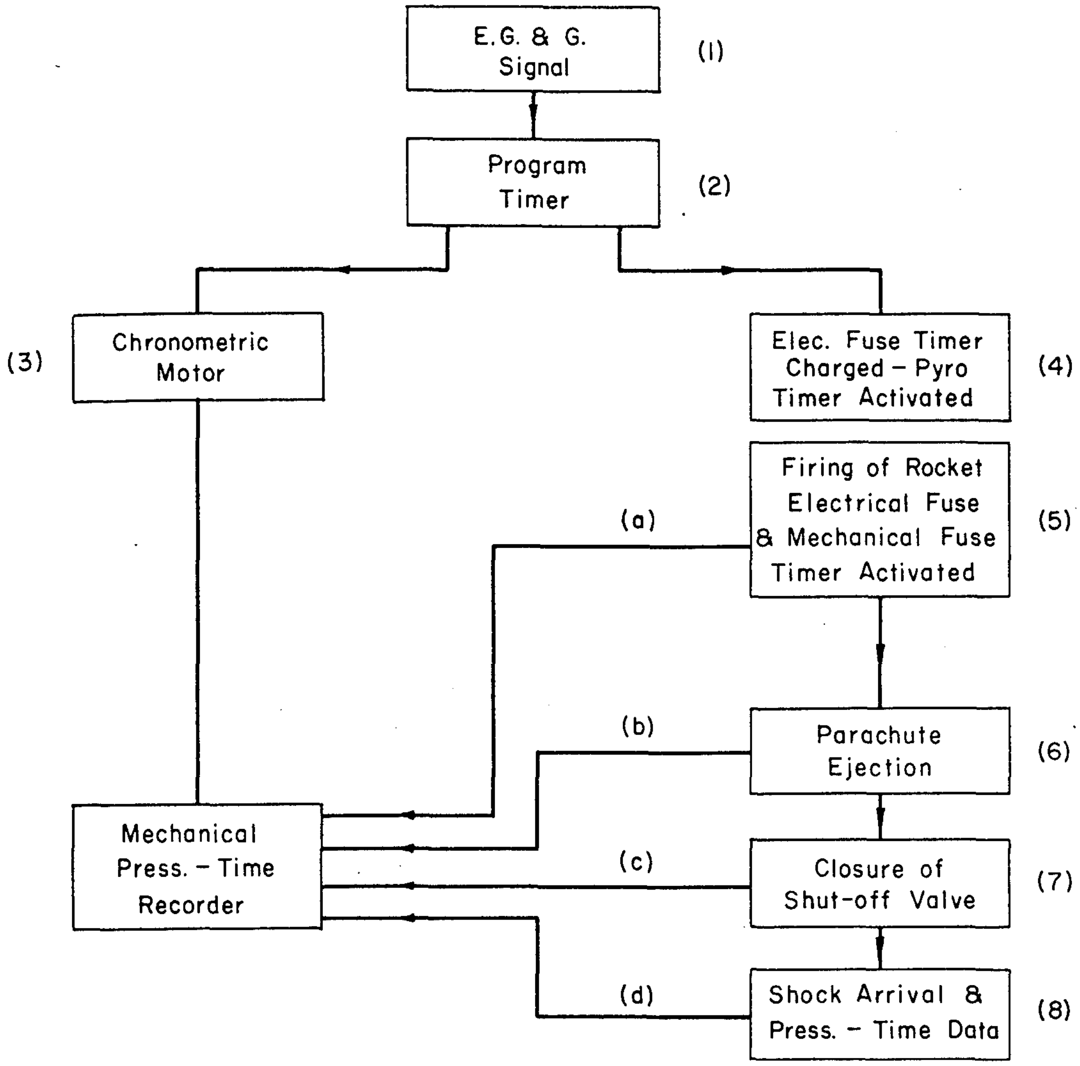

Figure 2.4 Block diagram of the sequence of events. The numbers indicate the chronological order of the events. The events indicated by the letters are recorded on the mechanical pressure-time recorder.

nals. The program-timer console is composed of a control circuit, time-base generator, 120-position relay, 120-point patch panel, output panel, 24-volt power supply, 600-volt power supply, and a time-set panel for the electric fuse timers. The program timer is shown in Figure 2.5, and block diagram is given in Figure 2.6.

A time signal at H minus 30 minutes was used to turn on the 600-volt power supply, which charged the fuse timers through the time-set panel and output panel. A time signal at H minus 60 seconds turned on the time-base generator.

Pulses from the time-base generator advanced the stepping relay one position on each half second. Each position was brought out to the patch panel providing a 24-volt firing pulse lasting for a half second. The beginning of the firing pulse was accurate to within 50 msec of the specified time. The selected pulses were patched into the output panel for connection to the appropriate rocket.

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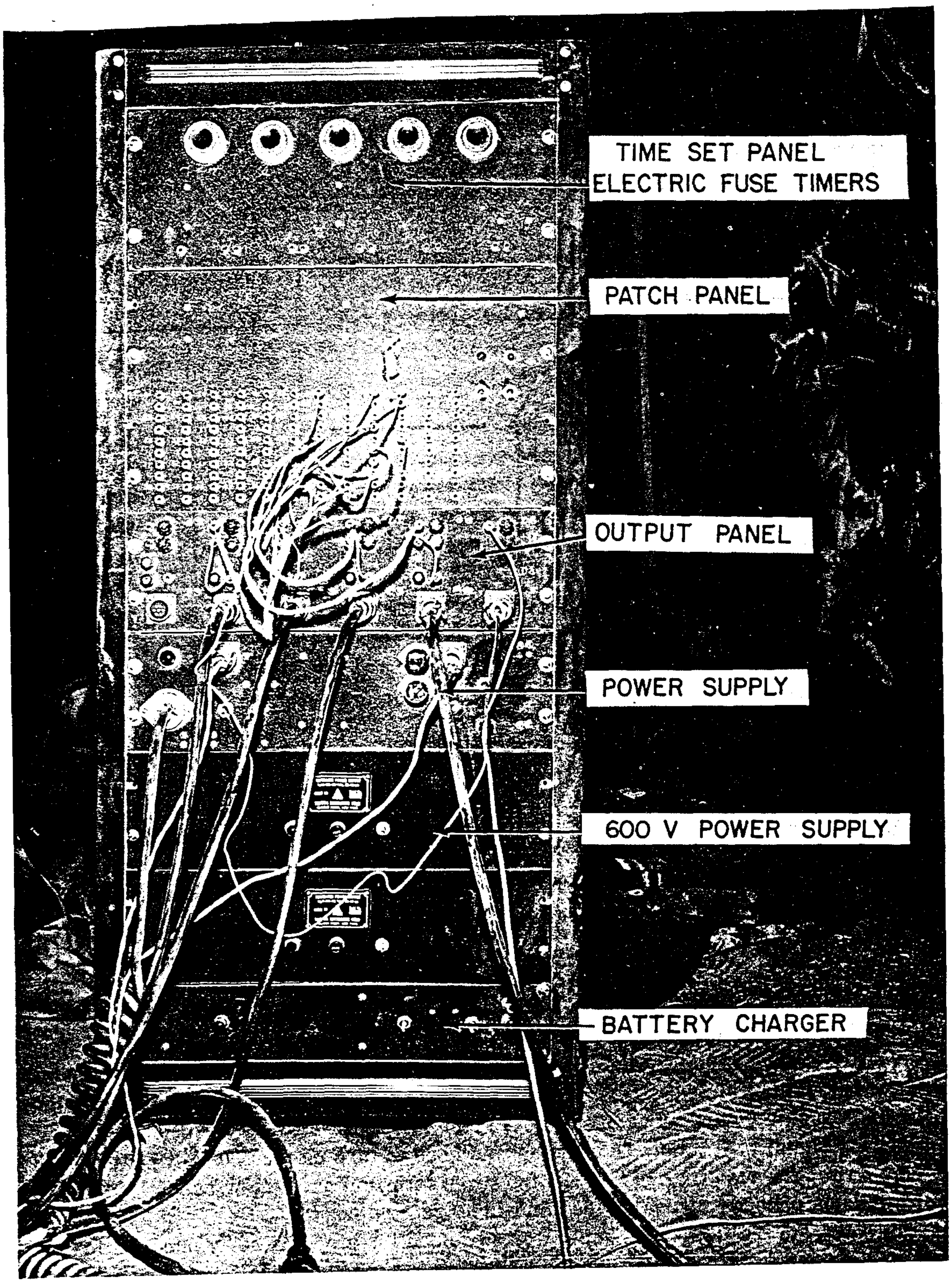

Figure 2.5 The firing programmer console.

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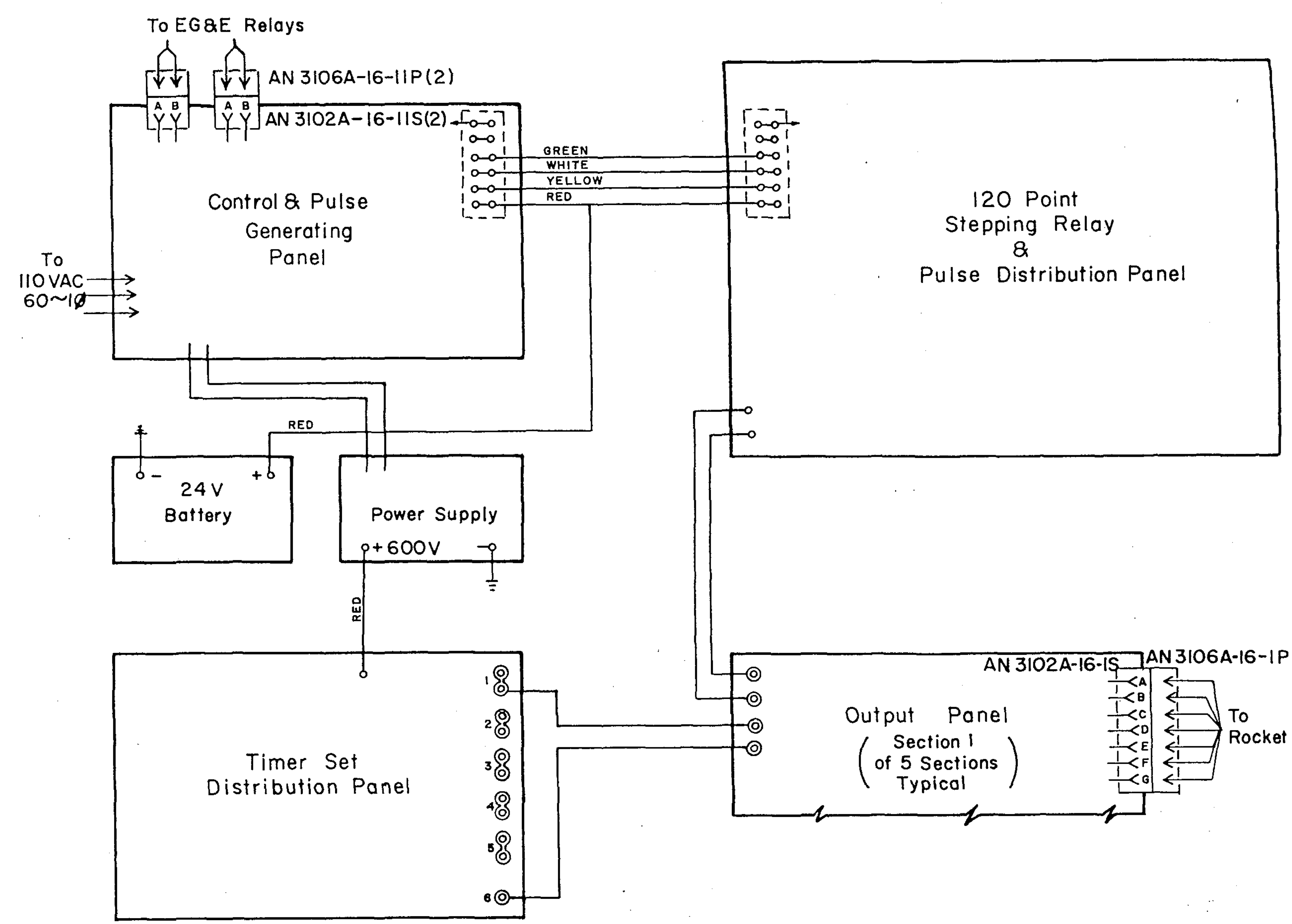

Figure 2.6 Block diagram of program timer.

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Three types of timers were used to activate the rocket separation. The electric timer is a modified NOL XP-54A Electric Timer Fuze, which utilizes an RC circuit. Time setting of the fuse is controlled by the ratio of charging voltages across two condensers within the timer. The timer is charged prior to firing the rocket, and it is initiated by an explosive switch, which is closed at the time of rocket firing.

The Raymond Engineering Laboratory timers are small electrical-mechanical devices, used to back up the NOL electric timers. The Raymond timers were connected to operate in parallel with the electric timers and were set for a slightly later release time. The Raymond timers specifications are as follows:

MODEL	1060
Method of starting	Inertia (9 G' s)
Timing range	0 to 30 seconds
Timing accuracy	2 percent of set time
Timing mechanism	T-3 clock
Electrical mechanism	Single-pole switch

Pyrotechnic time delays of longer time settings than either the electrical or mechanical timers were used to fire in parallel with the other timers as a backup for separation. Insofar as the other types of timers were experimental, it was felt necessary to use a very-reliable, though less accurate, system in case of failure of the other types of timers.

2.1.2 Balloon System. The balloon (Jalbert JX9) is a kytoon type that is 24 feet 10 inches long with a maximum diameter of 122 inches. The static lift is 50 pounds when the balloon is filled with helium.

One balloon was flown at an altitude of 200 feet, and an instrument canister containing the pressure-sensing-and-recording systems was attached to the mooring cable at an altitude of 25 feet (see Figure 2.7). A two-conductor electrical cable ran from the in-

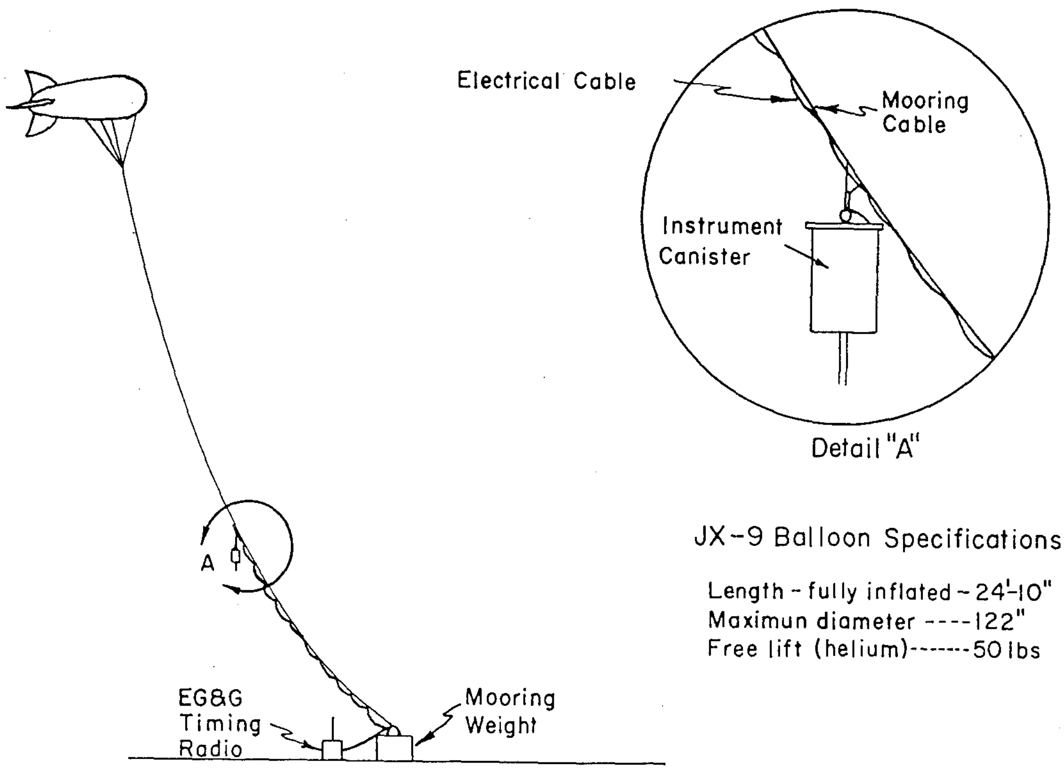

Figure 2.7 Balloon rig.

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strument canister to an EG&G timing signal radio receiver on the ground. Timing signals were received at minus 5 seconds and minus 1 second. The minus-5-second signal closed a relay, furnishing a voltage pulse that started the recording system, sealed the instrument canister, and activated the time marker relay. The minus-1-second signal released the time marker relay, which provided a reference time from which shock arrival time could be determined.

2.1.3 Pressure System. The pressure system was a self-contained mechanical system that consisted of a static-pressure probe, an aneroid pressure-pickup capsule, an aneroid altimeter, a recording drum driven by a synchronous motor, a time-marker relay, and an explosive valve with a pressure-delay line (see Figures 2.8, 2.9, and 2.10). This system was similar to that used by the Air Force Cambridge Research Center during Operation Teapot (References 2 and 3).

The basic system was used in both the rockets and in the balloon canister.

Operation. The recorders in the rockets were activated prior to the launch. Prior to the arrival of the shock wave, the recording drums were started by explosive switches, the instrument containers were sealed by explosive valves, and the time-marker relays were actuated. The shock wave entered the interior of the pressure pickup by way of the static pressure probe (see Figure 2.10), and a stylus, attached to the pressure pickup, made a scratch record of the shock wave on the recording drum. The ambient pressure within the instrument container was recorded on the drum by a stylus attached to the altimeter capsule. The times of the events indicated in Figure 2.4 were scratch recorded on the drum by a stylus attached to the time-marker relay. The recording drum, which operated for approximately 2 minutes, was cut off automatically by a limit switch.

Recording System. The recording system consisted of a chronometrically governed motor, a micrometer screw feed, and a recording drum. The motor drove the drum both radially and axially by means of the micrometer feed. Sapphire-tipped styluses, which were mounted on the pressure pickup, the altimeter, and the time-marker relay, made three parallel spiral traces on the recording drum. The recording drum was a highly polished stainless-steel sleeve coated with a thin layer of machinists' layout fluid and lubricated by Dow Corning No. 4 silicone grease.

Pressure Sensing. There were two pressure-sensing elements in the instrument container: a pressure-pickup capsule and an altimeter capsule. The pressure-pickup capsule measured shock overpressure with respect to the pressure within the instrument container, and the altimeter capsule measured the pressure within the instrument container. The instrument container was vented to atmospheric pressure through a pressure-delay line and an explosive valve. A few seconds prior to shock arrival, the explosive valve was actuated, sealing the instrument container. The delay line provided a lag time between equalization of pressure within the instrument container and the atmospheric pressure outside the container. This lag time, which was greater than the response time of the pressure pickup, allowed a shock overpressure to be measured in the event of explosive valve failure. The interior of the pressure-pickup capsule was vented to the static-pressure probe. The shock wave proceeded up the probe, deflected the pickup capsule, and was recorded on the drum. The deflection of the altimeter capsule at the time the explosive valve closed was recorded on the drum. By measuring these deflections on the drum, the magnitude of the shock overpressure and the altitude of the instrument were determined. Inasmuch as the drum was driven at a known constant speed, the duration of the positive phase of the shock wave was determined.

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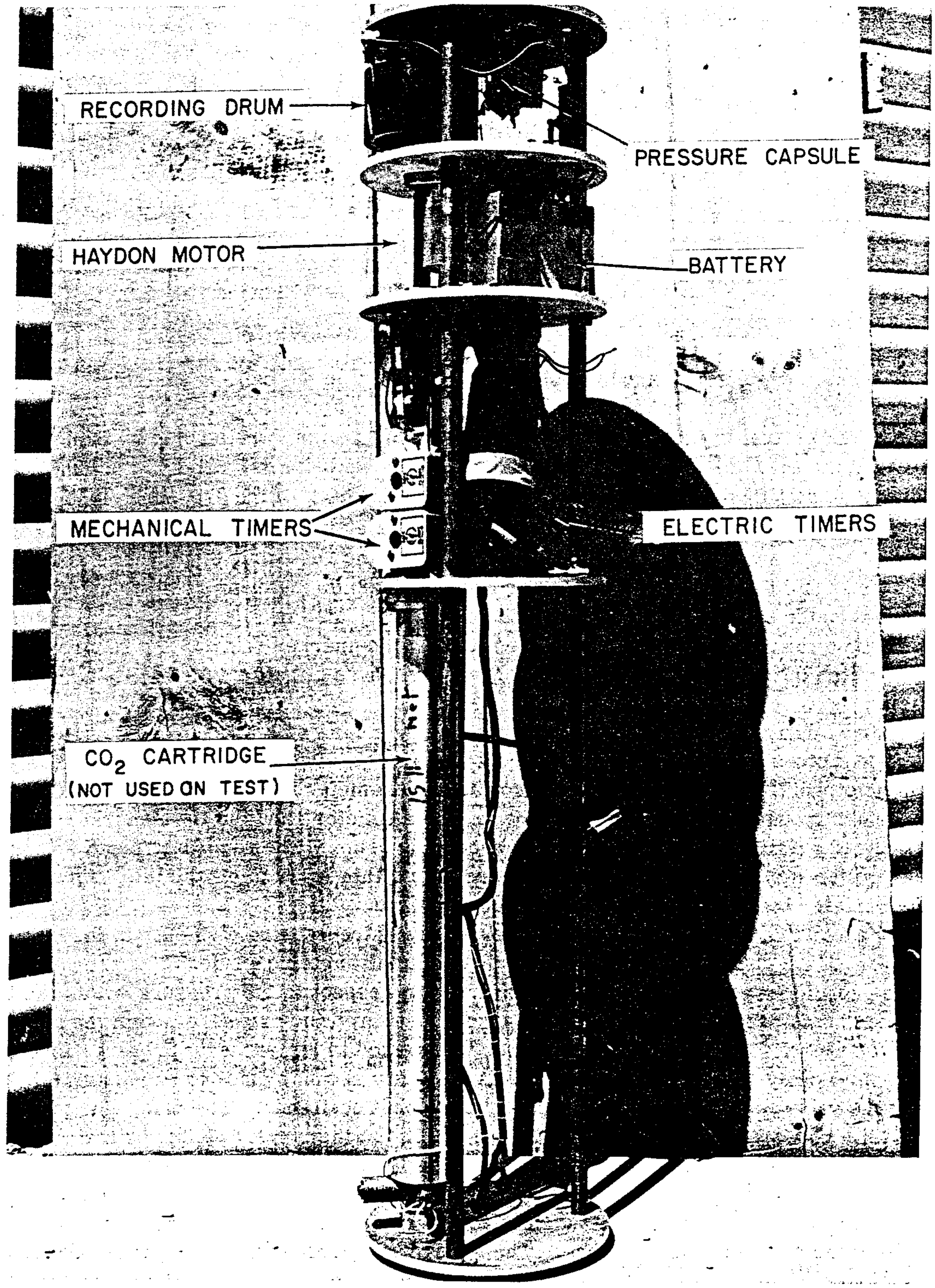

Figure 2.8 Rocket pressure and timing system.

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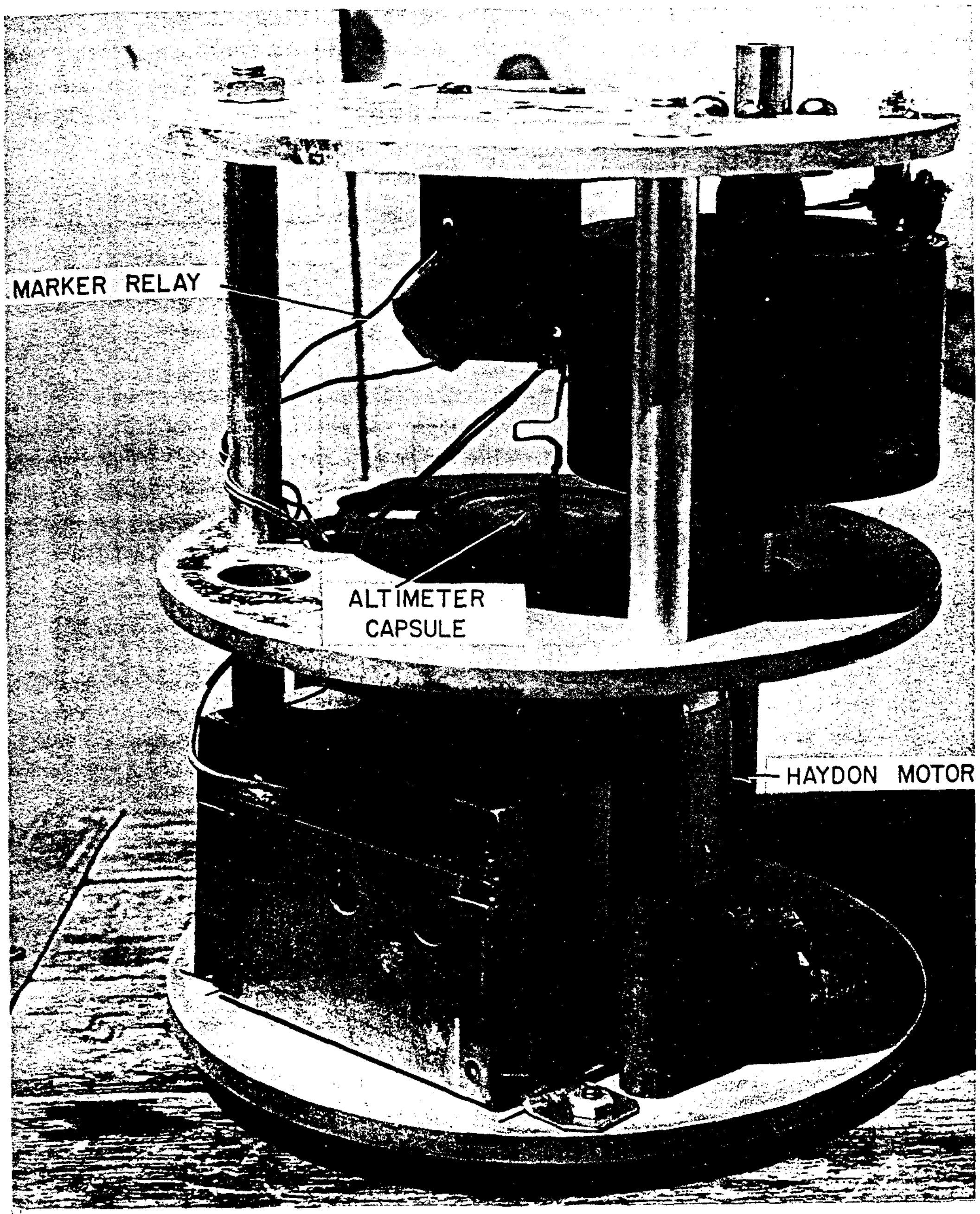

Figure 2.9 Balloon pressure and timing system.

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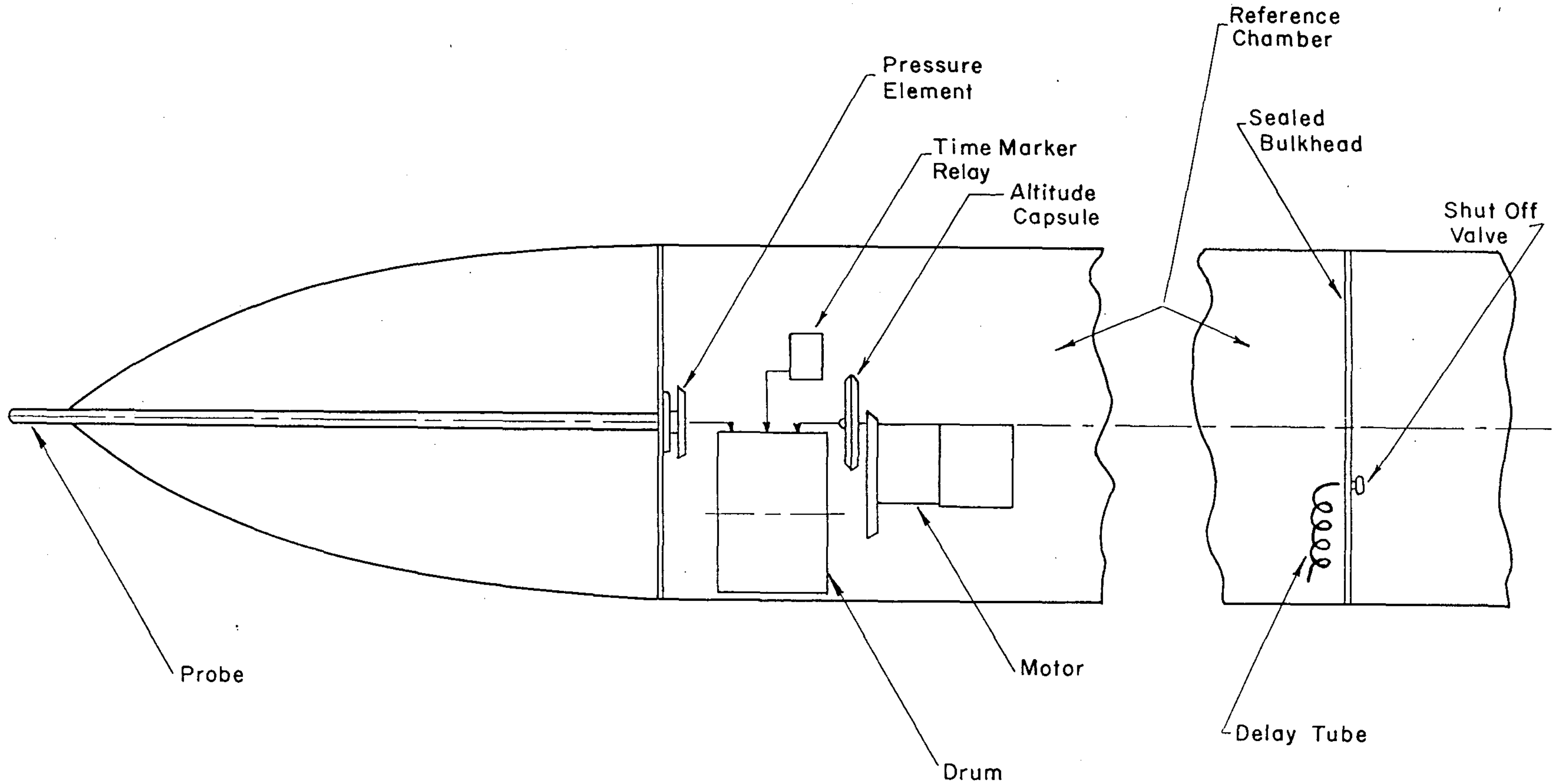

Figure 2.10 Schematic of recorder.

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2.2 PHOTOGRAPHIC INSTRUMENTATION

Photographic means were used to (1) obtain the positions of the parachute supported canisters, (2) determine the actual launching time of each rocket with respect to zero time, and (3) study the functioning of the balloon under shock loading. In Figure 2.1, the camera station positions are shown with respect to the rocket station, the balloon station, and ground zero. The camera plan is given in Table 2.1. All photography was carried out by EG&G.

TABLE 2.1 PHOTOGRAPHIC PLAN

Station		Camera			Aiming	Field of View Ft.	Remarks
No.	Location	Type	Lens	Speed			
1-356 (Owens)	N846,551 E671,736 Z 4,163	K-24	12 in	½ fps	R54°55' H +16°51' V	7,200 H 6,300 V	
		Mitch	50 mm	100 fps	R54°55' H +16°51' V	8,500 H 6,300 V	
4-357 (Owens)	N853,306 E651,033 Z 4,763	K-24	12 in	½ fps	L18°33' H +10°45' V	11,500 H 10,000 V	Parachute location system.
		Mitch	50 mm	100 fps	L18°33' H +10°45' V	13,600 H 10,100 V	All horizontal aiming angles in the location system are made with respect to T-4.
7-356 (Owens)	N860,590 E694,698 Z 4,537	K-24	12 in	½ fps	R19°44' H +15°16' V	8,000 H 8,000 V	
		Mitch	50 mm	100 fps	R19°44' H +15°16' V	9,500 H 7,100 V	
7-357 (Kepler)	N853,124 E678,005 Z 4,145	Mitch	254 mm	100 fps	L11°46' H + 4°35' V	800 H 600 V	Balloon coverage. Horizontal aim is with respect to T-2c.
Truck Sta. 352	Near	Mitch	254 mm	100 fps	0°00' H 15 pct foreground	N 300 H N 200 V	Qualitative launching studies and time of launch measurements.
(Owens)	N855,000 E675,000	Mitch	100 mm	100 fps	0°00' H 15 pct foreground	750 H 400 V	

Figure 2.10 Schematic of recorder.

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Chapter 3

RESULTS

3.1 ROCKET INSTRUMENTATION

The four instrumented rockets were fired and launched successfully. The firing schedule, aiming points (rocket separation point), and other pertinent data are given in Table 3.1.

Three of the rockets operated normally; the fourth, Rocket D, malfunctioned. The rocket separated normally, and the parachute deployed; but the after body overrode the parachute and became entangled, causing a fast average rate of descent (estimated to be no greater than 75 ft/sec). It is reasonable to assume that Rocket D separated at the designated height, because by all indications the separation timers functioned normally. The time of fall was known to be at least $1\frac{1}{2}$ minutes, since there was time for the recording drum to run to cutoff before striking the ground.

Figures 3.1 and 3.2 show the ground positions at which the instrument canisters and parachutes were recovered after firing. It can be seen that all the parachutes are displaced from the line of flight. This displacement is due to the wind drift of the parachutes in descending from their deployment altitudes. No altimeter readings were obtained from the recording drums (see Section 3.3). The estimated altitudes and slant ranges given in Table 3.2 were arrived at by the Project's assuming that, if the rocket separated at the time set on the electric fuse timers, it would be at the correct altitude. Examination of the four instrument canisters showed that at least one electric timer had operated in each rocket and all Raymond timers had functioned. In the case of Unit D, a 100-foot deviation from the calculated altitude is assumed, owing to the faster rate of descent. In all other cases, it was assumed that the parachutes descended 400 feet between deployment and shock arrival at H plus 7 seconds (estimated).

No malfunctions were apparent in either the M58 or the modified 5."0 HVAR engines.

The program timer functioned satisfactorily. A postshot test made on the equipment indicated that all events scheduled occurred at the designated times. An analysis of the films obtained of the launchings will be used to obtain the precise time of fire.

In general, the performances of the electric fuse timers and the mechanical timers were satisfactory. The general results of the functioning of the timers are given in Table 3.3.

Six of the electric fuse timers operated; two of the timers, which were from an early lot that had given erratic results during prior testing, failed to operate. An analysis of the functioning of the electric fuse timers is not possible in the field except on a go-or-no-go basis. The final evaluation will be carried out at NOL.

All of the mechanical timers operated. The performance was satisfactory. The timers in Rockets A, B, and C were not affected by the flight or the parachuted descent to the ground. The timers in Rocket D were damaged by the landing impact and could not be given a postflight check. Preflight and postflight data are given in Table 3.4.

Inasmuch as the electric fuse timers and the mechanical timers operated, the Marmon clamps had been blown free prior to the operation of the Pyrotimers. Hence, it is not possible to determine whether or not these timers operated. (Prior tests have indicated that the pyrotimers are very reliable.)

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TABLE 3.1 ROCKET FIRING SCHEDULE

				Aiming Point	
Rocket	Launch Angle	Firing Time	Parachute Deployment Time	Point of Deployment Ht. above Surface	Slant Range, Point of Deployment to Weapon at H – 3 sec.
				feet	feet
A	45°	H – 13 sec	H – 3 sec	3,300	10,000
B	55°	H – 18.5 sec	H – 3 sec	4,200	10,000
C	51°30'	H – 14.5 sec	H – 3 sec	6,000	10,000
D	65°	H – 28 sec	H – 3 sec	7,500	10,000

TABLE 3.2 ESTIMATED PARACHUTE POSITIONS

Rocket	Estimated Parachute Slant Range at Shock Arrival (H + 7 sec)	Estimated Parachute Opening Time	Estimated Parachute Rate of Descent	Estimated Parachute Altitude at Shock Arrival (H + 7 sec)
	feet		ft/sec	feet
A	9,920	H – 3 sec	40	2,900
B	9,850	H – 3 sec	40	3,800
C	9,750	H – 3 sec	40	5,600
D	9,700	H – 3 sec	70	7,000

TABLE 3.3 TIMING FUSE FUNCTIONING DATA

Rocket Number	A	B	C	D
Raymond Timer 1	Operated	Operated	Operated	Operated
Raymond Timer 2	Operated	Operated	Operated	Operated
Electric Fuse Timer 1	Operated	Operated	Operated	Operated
Electric Fuse Timer 2	Operated	Operated	Failed *	Failed *

* If either electric fuse timer operates or if any one of the timers operates the rocket will separate.

TABLE 3.4 MECHANICAL FUSE DATA

Raymond Timer No.	Pre-Flight Setting	Post-Flight Results	Rocket Number
	seconds	seconds	
312	11.5	11.5	A
315	11.0	11.1	A
317	16.8	16.6	B
313	17.0	16.8	B
314	13.0	13.0	C
318	12.1	12.1	C
310	26.5	Damaged	D
316	26.0	Damaged	D

TABLE 3.5 ROCKET AND BALLOON INSTRUMENTATION DATA

The ground surface is approximately 4,200 feet MSL.

Shot	Balloon Canister Number	Rocket Number	Slant Range to GZ	Distance Above Surface	Arrival Time	Peak Shock Overpressure
			feet	feet	sec	psi
Kepler	2		12,950	0	5.53	0.73
	4			25	9.5	0.72
Owens		A	9,900	2,900	2.42	0.75
		B	9,850	3,800	2.75	0.94
		C	9,750	5,600	Malfunctioned	
		D	9,700	7,000	2.83	0.65

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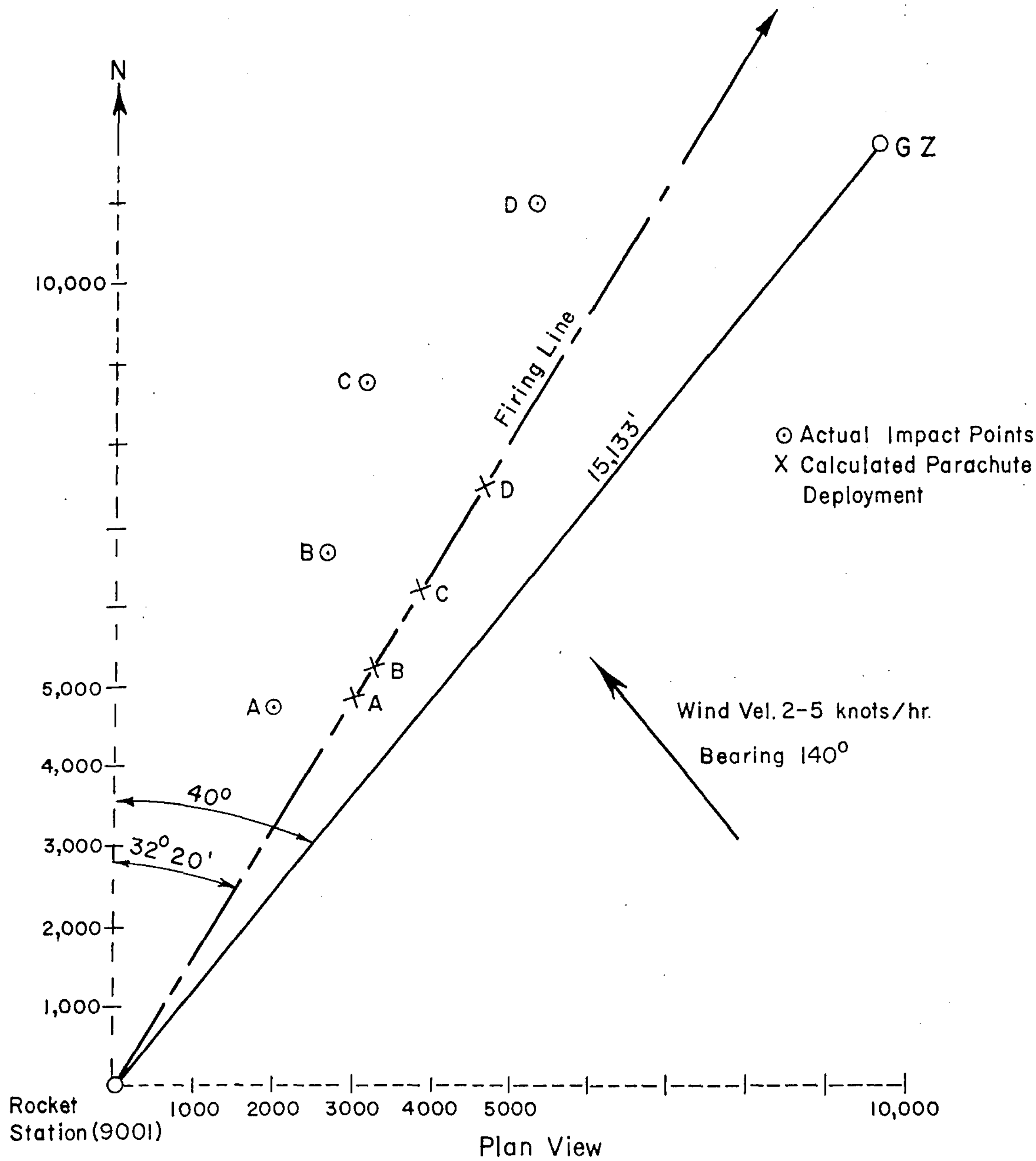

Figure 3.1 Rocket forebody impact locations.

[redacted]

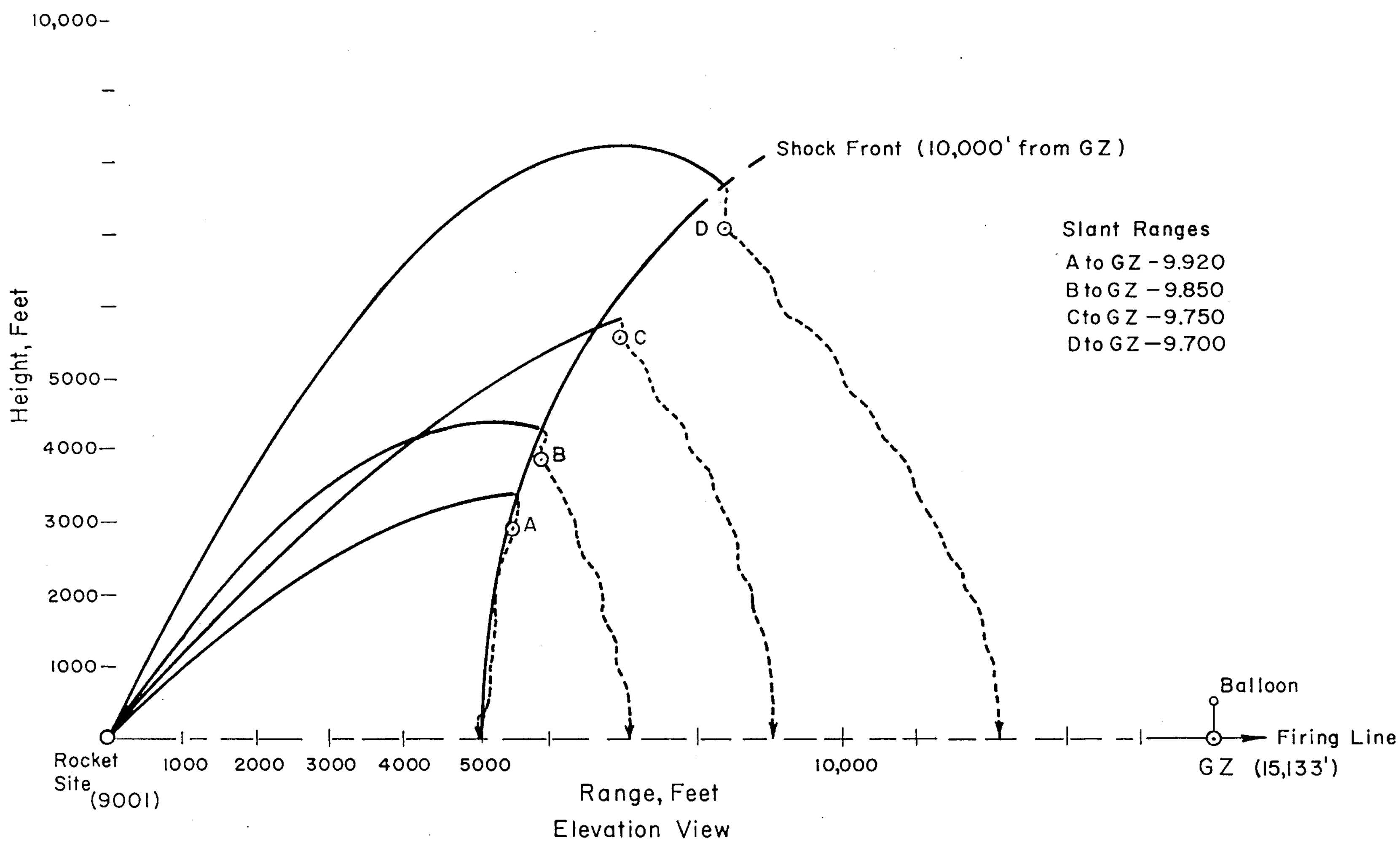

Figure 3.2 Rocket parachute deployment and impact points.

[redacted]

3.2 THE BALLOON SYSTEM

The balloon experiment was carried out on Shot Kepler rather than on Shot Owens. This change was made because of lengthy delays for Shot Owens. It was felt that by operating during Shot Kepler, rather than Owens, manpower and time could be conserved. The change of shots did not affect the experiment.

Initially it was planned to fly two Jalbert JX9 balloons rigged in tandem at 1,200 feet above the surface (approximately 5,400 feet MSL) in order to support two pressure gages at heights of 1,000 feet and 500 feet, respectively. However, in the course of experimenting with the balloons and in preparation for a shot, three of a total of four balloons were lost. Hence, with one balloon, it was felt the experiment should be limited.

The balloon was destroyed by the blast wave. However, a satisfactory pressure-time record was obtained. Even though the restricted experiment was successful, it is apparent that the balloon system must be revised for Operation Hardtack.

3.3 THE PRESSURE SYSTEM

The system used in both the balloon canisters and in the rockets performed satisfactorily. One gage, carried in Rocket C, malfunctioned; so a record was not obtained. The recording system functioned normally until the closure of the shut-off valve, at which time an electrical lead failed and shorted the battery. Pressure-time records were obtained by Rockets A, B, and D during Shot Owens and by both balloon gages used during Shot Kepler. A second balloon canister was mounted on the surface at the balloon station.

The wave shapes of the pressure-time records obtained were typical of a system of this nature. The rise time, in all cases, was approximately 8 msec long, which is in accordance with calculated response time of the system. Preliminary measurements made of the peak shock overpressures and arrival times are given in Table 3.5.

The shock-arrival times obtained by balloon Canister 2 during Shot Kepler and by Rockets A, B, and D during Shot Owens are incorrect. Considering the yield of Owens (11.1 kt) and the order of magnitude of the yield of Kepler, it would appear that these times are roughly 5 seconds low. The cause of this error is not known.

The pressures obtained by the two balloon gages are self consistent, and if the yield of Kepler were of the order of 10 kt, the pressure would appear to be reasonable.

The positions of the rocket gages at shock-arrival time are estimated. Using these locations, it appears all three gages were in the Mach region at arrival time and were at about the same slant range from air zero at different altitudes. The peak shock overpressure in the region covered by the gages would be greater than 0.5 psi, the approximate free-air pressure at a distance of roughly 10,000 feet from an 11-kt device, and probably less than 0.9 psi, the approximate free-air pressure at a distance of roughly 10,000 feet from a 22-kt device. The overpressure obtained by Rockets A and D fell within this region; considering the effect of the nonhomogeneous atmosphere, it is not unreasonable for the high gage Rocket D to record a lower pressure. The pressure obtained by Rocket B appears to be anomalous.

No usable data were obtained from the altimeters. The altimeters registered the change in altitude but were not sensitive enough for accurate measurement. Farther styluses on the altimeters vibrated during flight, particularly at the time of parachute deployment. It was also found that the altimeter record was too susceptible to any misalignment between the recording drum and the motor. This caused the traces to oscillate on the drum. The time-marker relay, which recorded the sequence of events, performed satisfactorily. However, it was found that action of the relay was not strong enough to make sharp pulses on the recording drum.

The traces made by the three styluses on the recording surface of the drum were satisfactory. The traces were made by the pressure capsule and the marker relay stylus, except when it was vibrating.

3.4 PHOTOGRAPHIC INSTRUMENTATION

Results of the photographic instrumentation are not available for this preliminary report (ITR).

[redacted]

Chapter 4

CONCLUSIONS

The objectives of the test were met. The air-blast-instrumentation system was tested under field conditions. The results of the test were satisfactory. A great deal of information was gained. The experience gained by personnel handling the equipment under field conditions was of the utmost value.

The fundamental design of the air-blast-instrumentation system is satisfactory.

The basic rocket is concluded to be an acceptable vehicle for deploying air-blast recording instruments. Aspects of the rockets that will require further work are: (1) cleaner separation of the forward body and the after body at parachute deployment; (2) a lighter, more-versatile rocket launcher to allow loading without the use of a derrick; and (3) a more-powerful motor for increased range and altitude.

The basic electrical design of the program timer is satisfactory. Future models will be more compact and will have provisions for sealing the unit against environmental conditions.

The basic circuitry and components in the rocket system are satisfactory and will provide the required sequence of operations. The multiplicity of timing mechanisms will not be required on future models. The timers to be used hinge upon the outcome of the laboratory investigation of the electric fuse timers.

The balloon experiment, which was limited, was successful; but in light of the experience obtained, it is apparent that the system must be improved. It will be necessary to lighten the load carried by the balloons.

The basic design of the pressure and recording system is sound. The changes which must be made are to (1) determine the source of and correct the arrival time errors; (2) increase the stiffness of the recording styluses to prevent excessive vibration and cause the styluses to rest on the drum at a constant pressure; (3) replace the altimeter capsule with a more-sensitive one; (4) replace the marker relay with one possessing a more-powerful movement; (5) increase the pitch of the micrometer screw to prevent overlapping records, and increase the motor speed; and (6) more-precisely align the shaft of the motor with the recording drum.

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